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(54) **EUTECTIC BASED CONTINUOUS THERMAL SENSING ELEMENT INCLUDING FIBER WRAPPED CENTER CONDUCTOR**

(71) Applicant: **Kidde Technologies Inc.**, Wilson, NC (US)

(72) Inventors: **Chris George Georgoulias**, Raleigh, NC (US); **Doug John Baxendell**, Clayton, NC (US)

(73) Assignee: **KIDDE TECHNOLOGIES, INC.**, Wilson, NC (US)

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,419,214 A * 4/1947 Holman G01K 13/06 219/155
2,610,286 A * 9/1952 Cox ..... H05B 3/56 174/117 F
2,732,479 A * 1/1956 Usa H05B 3/56 219/529
3,381,473 A * 5/1968 Kuehl C06B 33/00 149/5
3,743,986 A * 7/1973 McInturff H01B 12/10 174/125.1
3,818,412 A * 6/1974 Deardurff H01B 7/0063 156/52
4,435,692 A * 3/1984 Miyamoto ..... H01B 7/0063 174/120 SC

(Continued)

FOREIGN PATENT DOCUMENTS

DE 1621803 B * 3/1975
FR 2986777 A1 8/2013

(Continued)

OTHER PUBLICATIONS

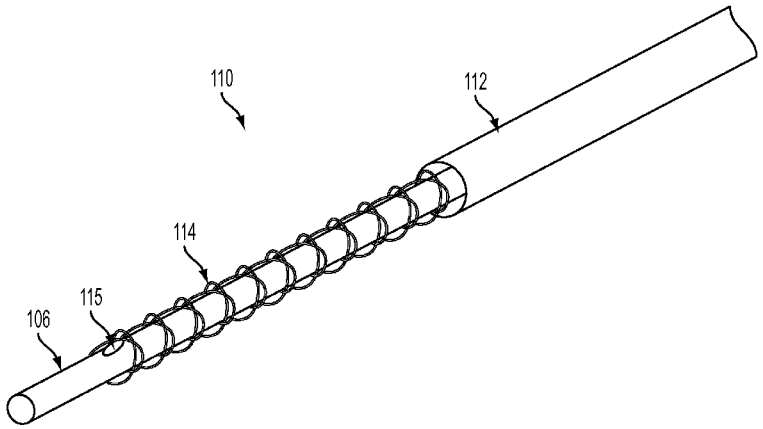
Extended European Search Report for corresponding EP Application No. 15198496.0-1555, dated Apr. 25, 2016, pp. 1-7.

Primary Examiner — Gail Kaplan Verbitsky
(74) *Attorney, Agent, or Firm* — Cantor Colburn LLP

(57) **ABSTRACT**

A eutectic sensing element includes an electrically conductive core extending along a first axis to define a length. The core is coated with a coated with a eutectic material formulated to provide desirable thermal response characteristics. The eutectic sensing element further includes an insulating fiber layer disposed on an external surface of the electrically conductive. The insulating fiber layer includes a strand that extends along the length of the electrically conductive core.

10 Claims, 3 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

4,795,998	A *	1/1989	Dunbar	G01L 1/205 338/208
4,800,359	A *	1/1989	Yukawa	H01C 3/20 338/214
5,015,958	A *	5/1991	Masia	G01M 3/045 174/11 R
5,034,719	A *	7/1991	Brown	H01B 7/0063 174/102 SC
5,418,516	A *	5/1995	Oh	H01H 85/048 338/21
2003/0210902	A1 *	11/2003	Giamati	H01C 1/08 392/444
2010/0118911	A1 *	5/2010	Lorrette	G01K 7/18 374/1

FOREIGN PATENT DOCUMENTS

GB	839037	A	6/1960	
GB	2484990	A	5/2012	
JP	62229161	A *	10/1987	G03G 9/1131
JP	2013237718	A *	11/2013	

* cited by examiner

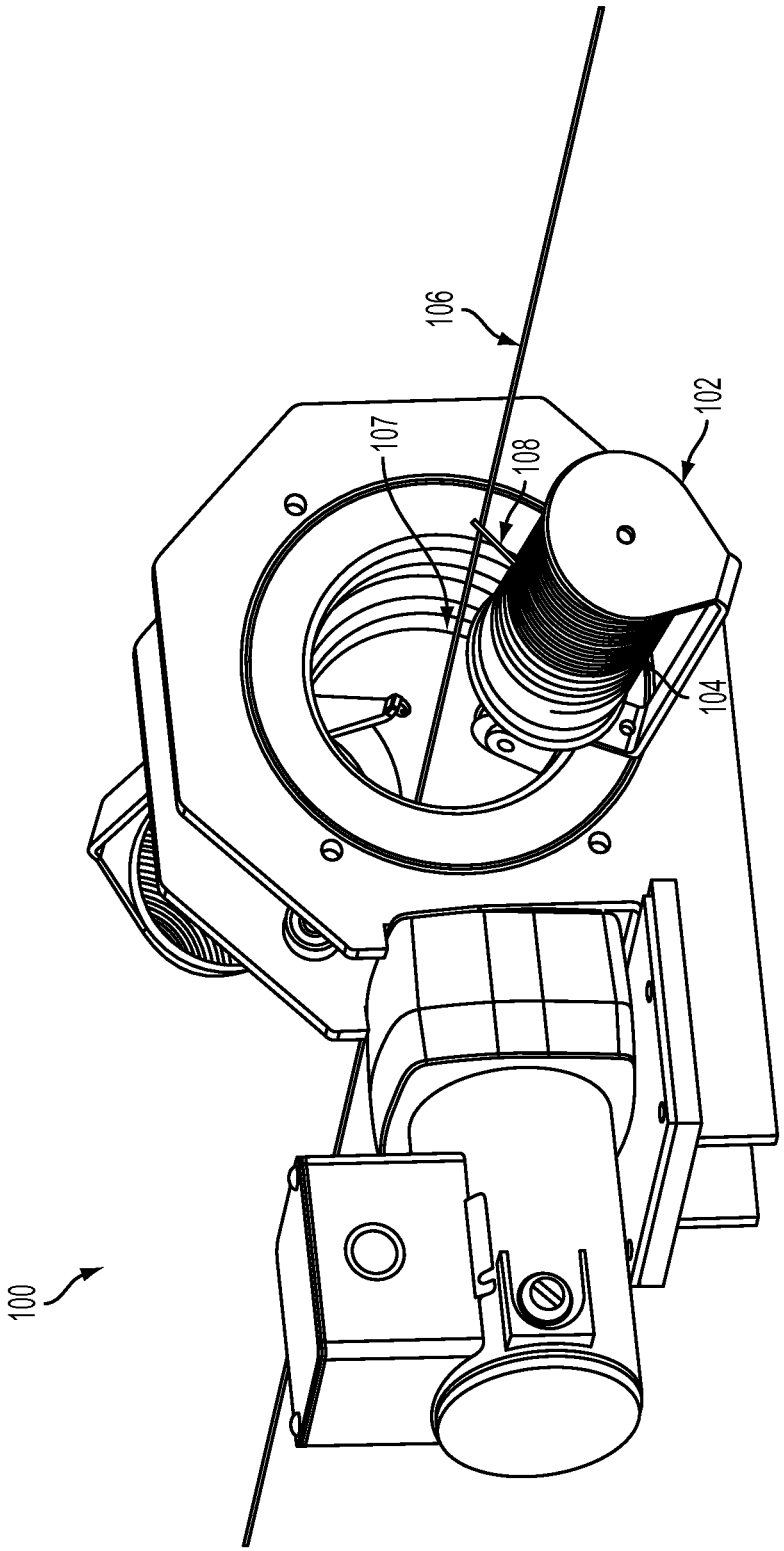


FIG. 1

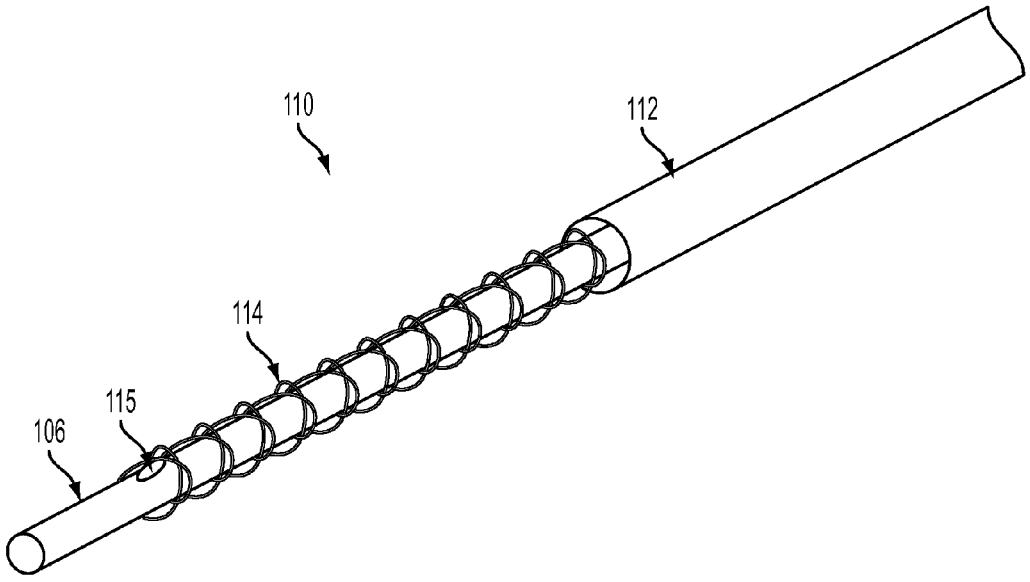


FIG. 2

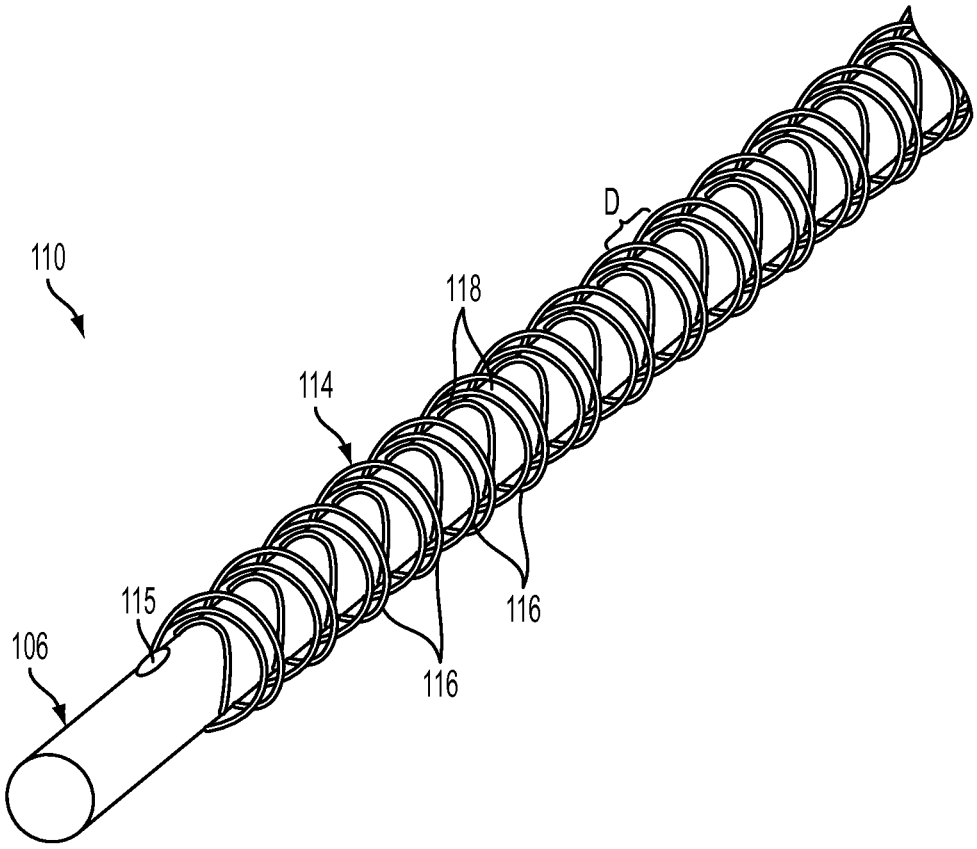


FIG. 3

EUTECTIC BASED CONTINUOUS THERMAL SENSING ELEMENT INCLUDING FIBER WRAPPED CENTER CONDUCTOR

TECHNICAL FIELD

The present invention relates generally to continuous sensing elements, and more particularly, to a continuous thermal sensing element including a fiber wrapped center conductor.

BACKGROUND

Eutectic based continuous thermal sensing elements are typically formed as a co-axial element including a center conductor such as a wire, for example. Current production methods for manufacturing continuous thermal sensing elements incorporate the application of tubular or crushed ceramic insulators as a means to isolate the center conductor from an outer covering or sheath. The tubular or crushed ceramic insulators, however, are susceptible to inconsistent and transient performance as the sensing element is manipulated and handled during processing and installation.

SUMMARY

According to a non-limiting embodiment, a eutectic sensing element includes an electrically conductive core extending along a first axis to define a length. The core is coated with a coated with a eutectic material formulated to provide desirable thermal response characteristics. The eutectic sensing element further includes an insulating fiber layer disposed on an external surface of the electrically conductive. The insulating fiber layer includes a strand that extends along the length of the electrically conductive core.

According to another non-limiting embodiment, a method of forming a eutectic sensing element comprises coupling a first fiber end of an insulating fiber strand to a first core end of an electrically conductive core. The method further includes wrapping the insulating fiber strand along a length of the electrically conductive core. The method further includes coupling a second end of the insulating fiber to a second core end of the electrically conductive core such that the insulating fiber forms a spiral-shaped insulating fiber layer.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** illustrates a fiber wrapping apparatus configured to wrap an insulating fiber around an exterior surface of a core extending through a wrapping vicinity;

FIG. **2** illustrates a sensing element including a core disposed in a sheath, and an insulating fiber layer wrapped on an outer surface the core; and

FIG. **3** is a close up view of a conductive core including an insulating fiber layer wrapped according to a spiral arrangement on an outer surface thereof to form a plurality of fiber segments that define gaps between each pair of fiber segments.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. **1**, a fiber wrapping apparatus **100** is illustrated according to a non-limiting embodiment. The fiber wrapping apparatus **100** includes a spool **102** loaded with insulating fiber wrapping **104** (i.e., a wound strand). The insulating fiber wrapping **104** may be formed from various insulating materials including, but not limited to, ceramic and glass. An electrically conductive core is coated with a eutectic material such as, a eutectic salt material for example, and is fed to a wrapping vicinity **107** to form a eutectic sensing element. According to an embodiment, the fiber wrapping apparatus **100** moves axially along the length of the core **106** while wrapping an insulating fiber strand **108** directly on the outer surface of the core **106**. According to another embodiment, the wrapping apparatus **100** remains fixed and the fiber strand **108** is wrapped directly on to the outer surface of the core **106** as the core **106** is fed axially past the spool **102**.

Turning now to FIG. **2**, a continuous eutectic sensing element **110** is illustrated according to a non-limiting embodiment. The eutectic sensing element **110** includes a core **106**, a sheath **112**, and an insulating fiber layer **114**. The core **106** can be formed of various high temperature conductive materials including, but not limited to, steel or nickel. The sheath **112** is formed from, for example, from a nickel-based alloy such as Inconel 625. The core **106** has a first diameter and the sheath **112** has a second diameter greater than the first diameter. Accordingly, the core **106** may disposed within the sheath **112**. According to an embodiment, the sheath **112** comprises an electrically conductive material.

The insulating fiber layer **114** can be formed as a single strand or a matrix threading of an insulating material including, but not limited, to glass or ceramic. The insulating fiber layer **114** extends along the length of the core **106** and between an end of the sheath **112** and a contact terminal **115** formed at an end of the core **106**. The sheath **112** may be disposed over the insulating fiber layer **114** and the core **106** coated with the eutectic material, to form a co-axial continuous eutectic sensing element **110**. In this manner, the insulating fiber layer **114** isolates the core **106** from the sheath **112**.

Referring to FIG. **3**, a close up view of a core **106** included in a eutectic sensing element **110** is illustrated. The core **106** includes an insulating fiber layer **114** wrapped directly thereon. The insulating fiber layer **114** is wrapped in a spiral arrangement that forms a plurality of fiber segments **116** and defines gaps **118** between each pair of fiber segments **116**. The distance of the gaps **118** can be varied based on how close together (i.e., how tight) each fiber segments **116** is wrapped on the core **106** with respect to one another. The distance of the gaps **118** (i.e., the distance between each fiber segments **116**) may control the time constant of the eutectic sensing element **110**, and may also control the consistency/sensitivity of the eutectic sensing element **110**. For example, both the delay of the time constant and consistency/sensitivity may increase as the gap length, i.e., distances (d), decrease. Alternatively, the delay of the time constant and consistency/sensitivity decrease as the gap distances (d) increase. Further, the insulating performance provided by the insulating fiber layer **114** is Insulating performance is inversely related to gap distance. For example, the insulating performance increases or decreases as the distance (d) of the gaps **118** decrease or increase, respectively.

While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

The invention claimed is:

1. A eutectic sensing element, comprises:

an electrically conductive core extending along a first axis to define a length; and

an insulating fiber layer disposed on an external surface of the electrically conductive core, the insulating fiber layer including a strand that extends along the length of the electrically conductive core,

wherein the electrically conductive core is coated with a eutectic material formulated to provide desirable thermal response characteristics, and the strand includes a plurality of fiber segments that define a plurality of gaps between each fiber segment, wherein a gap length of each gap controls a delay of a time constant of the eutectic sensing element.

2. The eutectic sensing element of claim **1**, wherein a number of segments among the plurality of fiber segments controls insulating performance of the eutectic sensing element.

3. The eutectic sensing element of claim **2**, wherein the strand comprises ceramic.

4. The eutectic sensing element of claim **2**, wherein the strand comprises glass.

5. The eutectic sensing element of claim **2**, further comprising a sheath surrounding the electrically conductive core, the insulating fiber layer interposed between the electrically conductive core and the sheath.

6. A method of forming a eutectic sensing element, the method comprising:

coupling a first fiber end of an insulating fiber strand to a first core end of an electrically conductive core;

wrapping the insulating fiber strand along a length of the electrically conductive core; and

coupling a second end of the insulating fiber to a second core end of the electrically conductive core such that the insulating fiber forms a spiral-shaped insulating fiber layer;

wherein the strand includes a plurality of fiber segments that define a plurality of gaps between each fiber segment, and wherein a gap length of each gap controls a delay of a time constant of the eutectic sensing element.

7. The method of claim **6**, further comprising adjusting the insulating performance of the eutectic sensing element based on a number of segments among the plurality of fiber segments.

8. The method of claim **7**, further comprising forming the strand from ceramic.

9. The method of claim **7**, further comprising forming the strand from glass.

10. The method of claim **7**, further comprising coating the electrically conductive core with a eutectic material and disposing a sheath around the electrically conductive core such that the insulating fiber layer is interposed between the electrically conductive core and the sheath.

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